

valves of different descriptions we find much valuable information, including the piston type of valve, largely used at sea, and now, under the name of Smith's Patent, being experimented with on the North-Eastern and Midland Railways, the Highland Railway having tried and discarded it some short time ago. Valve gear in detail comes next, and we cannot agree with the author when he says that in inside cylindered engines expansion links with one bracket only are used. This is the exception and not the rule—*vide* the practice of the Brighton, Caledonian, and North British Railways.

Taken as a whole, the descriptions of all detailed work represent modern practice, and the engineering student will find much to learn in these pages. Chapter xiii. deals with the all-important question of the general construction and design of the locomotive boiler; after discussing the questions which really concern its dimensions, the question of various types is described. The now fashionable Belpaire type is badly illustrated in Fig. 155, which must represent an American or continental type of boiler, although the author does not say so, and the arrangement of stays and plating is certainly not of British design. The Belpaire boilers designed by Messrs. Neilson, Reid, and Company for the Mexican railways some years ago might be taken as fair representatives of this type of British design, and should be illustrated in a future edition—they being the prototype of some running on more than one British railway.

In order to allow freedom for expansion of the tube-plates of Belpaire boilers of British design, it is usual to arrange the last transverse rows of vertical stays so that any vertical movement of the fire-box will not be transmitted to the wrapper-plate; moreover, a similar arrangement might be placed above the door-plate with advantage.

On the use of steel in boiler construction we find much valuable information, but we most distinctly disagree with the author when he states on p. 200 that steel of boiler-plate quality contains a maximum of 15 per cent. and a minimum of 10 per cent. of carbon! What has happened to the decimal point? The author, like many others, has not yet got over the idea that steel-plates require very special treatment in the flanging-shed and boiler-shop. This is not the case; steel-plates, as manufactured to-day, are more uniform in quality, and are certainly as easily worked as Yorkshire iron. On p. 215 we read that on the Caledonian Railway the roof of the fire-box is supported by vertical stays fastened in series of threes in a longitudinal direction. These stays were on the scrap heap years ago.

On the question of machine riveting, our author maintains that subsequent caulking of rivet-heads is unnecessary. If this is the case, why do our best firms of locomotive builders invariably carefully caulk every rivet-head before the boiler is tested? They work for a profit, not for honour and glory.

Mr. Ravenshear gives a very full description of continental and American locomotive practice, with illustrations, which will be found towards the end of this volume, besides the usual descriptive accounts of the vacuum and Westinghouse railway brakes. Taken as a whole, this work is one of the best of its kind

that has been published on the subject. The strains experienced by various parts of a locomotive during work are impossible to calculate, and, therefore, it must be every-day experience that can train the successful designer. For this reason a text-book on this subject can only be descriptive of work done which successfully withstands the usages of every-day work.

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#### THE HEREFORD EARTHQUAKE OF 1896.

*The Hereford Earthquake of December 17, 1896.* By Charles Davison, Sc.D., F.G.S. Pp. xi + 303. (Birmingham: Cornish, 1899.)

AFTER an interval of more than two years Dr. Charles Davison has at last given us, in a volume of 303 pages, his long-promised account of the earthquake which, in the early morning of December 17, 1896, rudely awakened the inhabitants of the Severn Valley.

When we look at the 2902 epitomised accounts which Dr. Davison has brought together respecting an earthquake which in many countries would have been regarded with as much indifference as a sprinkling of rain, we are inclined to ask whether the examination of this long series of remembrances, obtained from a community more or less excited by phenomena with which they had but little experience, would be likely to lead to results of any value. Had this earthquake originated in a sparsely populated country where there were difficulties in obtaining accurate time, the analysis of observations taken under such conditions would, to a large extent, have been labour in vain.

Although no special provisions are taken in Britain for the observation of earth tremors, as the one now under consideration occurred at the waking hour of many millions of people who, lying on their beds, were in the best possible position for noticing slight vibrations, and for the most part had the means of obtaining fairly good time, and above all were intensely interested in the phenomenon they experienced, the conditions for obtaining a large series of valuable records were unusually favourable. Within the epifocal area where chimneys fell or were "hurled to some distance"—which we doubt—and buildings were unroofed, and within at least one hundred miles of the same, all the observers had but little doubts as to the nature of the movements they experienced. Beyond these limits in very many instances it is likely that many observers only realised and remembered that a something or other had rattled, perhaps the window or a lamp-shade, after they had read their morning papers, and with feelings of satisfaction as participants in an alarming disaster, they threw in their notes and helped to complete an important chapter in British seismology. If every time a window was slightly shaken, glasses rattled, or other unaccountable microphonic disturbances were perceptible could be recorded, and the collected results analysed, it is extremely probable that the seismic register for the British Islands would be considerably increased.

Before discussing the catalogue of observations, Dr. Davison sets out by showing that there is a reality of connection between the majority of earthquakes and the

slow but intermittent growth or extension of faults. This done, he draws on a map isoseismals or curves surrounding all places at which the intensity of the movement, as represented in certain cases by its destructivity, has been approximately equal. The most important of these is isoseismal number 8, which is the innermost and contains some seventy-three places at which there was structural damage. It is oval or elliptical in form, with its major axis forty-three miles in length running from N.W. to S.E., and encloses the towns of Hereford, Ross and Gloucester. Outside this are the isoseismals numbered 7, 6, 5 and 4, a series which become more and more circular in form, the latter extending beyond Wexford and Dublin in the west, and Norwich on the east.

From the form of these isoseismals, especially that of No. 8, which is the most important, by reasoning familiar to seismologists it is shown that the disturbance originated along a line of fault which dips to the north-east, and has a strike coinciding with the major axis of the innermost of these curves of equal intensity.

It appears that two series of vibrations were noted, which at different places were different in intensity and duration. An examination of the records relating to these leads to the conclusion that the principal shock originated from two foci along the line of fault, one near to Hereford, and the other near to Ross.

At this point Dr. Davison is hand in hand with the geologist who, having already mapped faults bounding the triangular area of May Hill, south-east of Hereford, now sees that there are good reasons for supposing that one of these is but the south-eastern extension of that revealed by the distribution of vibrational effects accompanying the Hereford earthquake. Davison's fault therefore throws new light upon the geotectonic relationships amongst the older rocks in Western Britain, and that there is such a rupture in the Old Red Sandstone to the east of Hereford may at any time be of importance not only to the geologist but to the engineer.

Another set of lines discussed are those passing through places at which the same phase of the earthquake was felt at the same instant. These are the well-known coseismal lines, which are less elongated than the isoseismals, but have their major axis in approximately the same direction. From the distances between them, velocities of transit varying between 2814 and 3095 feet per second are calculated, suggesting, but not on very certain grounds, an apparent increase in the velocity of earthquake transmission as it radiates. With a knowledge of the velocity between any two coseismals and the distance of one of them from the epicentre, the time of origin of the earthquake is determined as having been at 5h. 31m. 45s. a.m.

To the seismologist, the most striking feature in Dr. Davison's work is his treatment of the sound phenomena. Mr. Mallet in his classical work on the Neapolitan earthquake of 1857 gives us a chapter on the sounds that attend a shock, and which are produced by steam or by the rending of rocks. In a previous publication, Dr. Davison has given us his views as to the origin of earthquake sounds, which he attributes to the slipping or mechanical disturbance in the marginal region of the seismic focus.

In the present work, he gives us a map showing isacoustic lines or lines of equal sound intensity. Any one of these lines passes through districts in which the percentage of observers who noted a sound are equal, and they are therefore more strictly speaking, as the author states, lines of equal sound audibility.

The major axis of these closed curves is, roughly speaking, at right angles to that of the iso- and coseismal curves. More accurately it is a hyperbolic trace which follows the band, along which it is shown that the two series of vibrations from the two earthquake foci are superimposed.

The general result arrived at from the study of these isacoustic lines is that they confirm the conclusion that there were two distinct, or nearly distinct, regions along the fault line from which vibrations radiated, and that the slip at the northern end of this line occurred a few seconds earlier than at the southern end. In this discussion of sound phenomena we have something distinctly original.

The shock was felt less upon hard rocks and on high ground than on soft ground and in valleys. In the Bangor-Anglesey district the shock was felt most powerfully upon the carboniferous and ordovician rocks, and less upon the volcanic materials and schists. It was felt underground in several mines; at some places it produced feelings of nausea, and many instances are recorded of horses, cows, dogs, sheep, pheasants and other birds having exhibited symptoms of alarm.

Without going further into Dr. Davison's work, taking the same as a whole, he is to be congratulated on having extracted from materials which at first sight are of very little promise a quantity of valuable and novel information. The Hereford earthquake was a transient shivering of an exceedingly small portion of the earth's crust; and, considering that there may be 10,000 of these occurring every year, this one appears to have been more carefully studied than any of its predecessors of equal magnitude.

Had the author contented himself with analysing half the facts he has collected, although the same would have made a column of print 100 yards in length, the probability is that, beyond noting a number of incidents of local interest, our knowledge of seismic phenomena would have not been materially increased. As it is, especially perhaps with regard to isacoustics, a distinct advance has been made, and in the future we shall find others working on similar lines.

J. MILNE.

#### A BIOLOGICAL RECORD.

*L'Année Biologique.* Comptes rendus annuels des travaux de Biologie générale, publiés sous la direction de Yves Delage, professeur à la Sorbonne, avec la collaboration d'un Comité de Rédacteurs. Secrétaire de la rédaction, Georges Poirault, Docteur ès sciences. Première année (1895). Pp. xlv + 732. 1897. Deuxième année (1896). Pp. xxxv + 808. 1898 (Paris : Schleicher Frères.)

IN one of the Woods Holl Biological Lectures, entitled "Bibliography: a Study of Resources," Dr. Charles Sedgwick Minot, himself the author of one of the standard zoological bibliographies, compares the biological biblio-